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COGEAR: COupled seismogenic GEohazards in Alpine Regions

COGEAR

MODULE 3:

Overview of existing data in the Matter valley

Del. No.: 3b.2.1

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COGEAR
Deliverable 3b.2.1 Overview of existing data in the Matter valley

Digital/Digitized site information and digital/digitized maps (del:3b.2.1.2)

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Introduction:

Deliverable 3b.2.1 provides an overview of existing data, including digital meta-data and maps, related to COGEAR Module 3b.2 – *Topographic Amplification and Non-linear Response of Rock Slopes*. This deliverable is divided into two primary sections. The first section provides a brief overview of existing data from public sources relative to the COGEAR Project including topographical, geological, geophysical, geotechnical and tectonic data within the focus region of Module 3b. The second section describes the available data based on previous work performed by the Engineering Geology Group and research partners that is relative to COGEAR and integrated into the COGEAR database developed within Module 1.

References and relevant figures from these references are linked to this report as either pdf files or digital images. A static image of data is provided within the data description as a link to this report. The digital data is maintained on the Engineering Geology Server and can be requested through the Engineering Geology group if needed by COGEAR partners. The “Reference link” folder should be placed in the same location as the report document to maintain the correct hyperlinks.

The primary area covered in the report is highlighted in Figure 1 and extends from Staldin VS. past Zermatt within the Matter valley and from Stalden past Mattmark reservoir in the Saas Valley. The data within the Saas Valley is limited to the Quaternary development of the valley slopes associated with glacial advance and retreat.

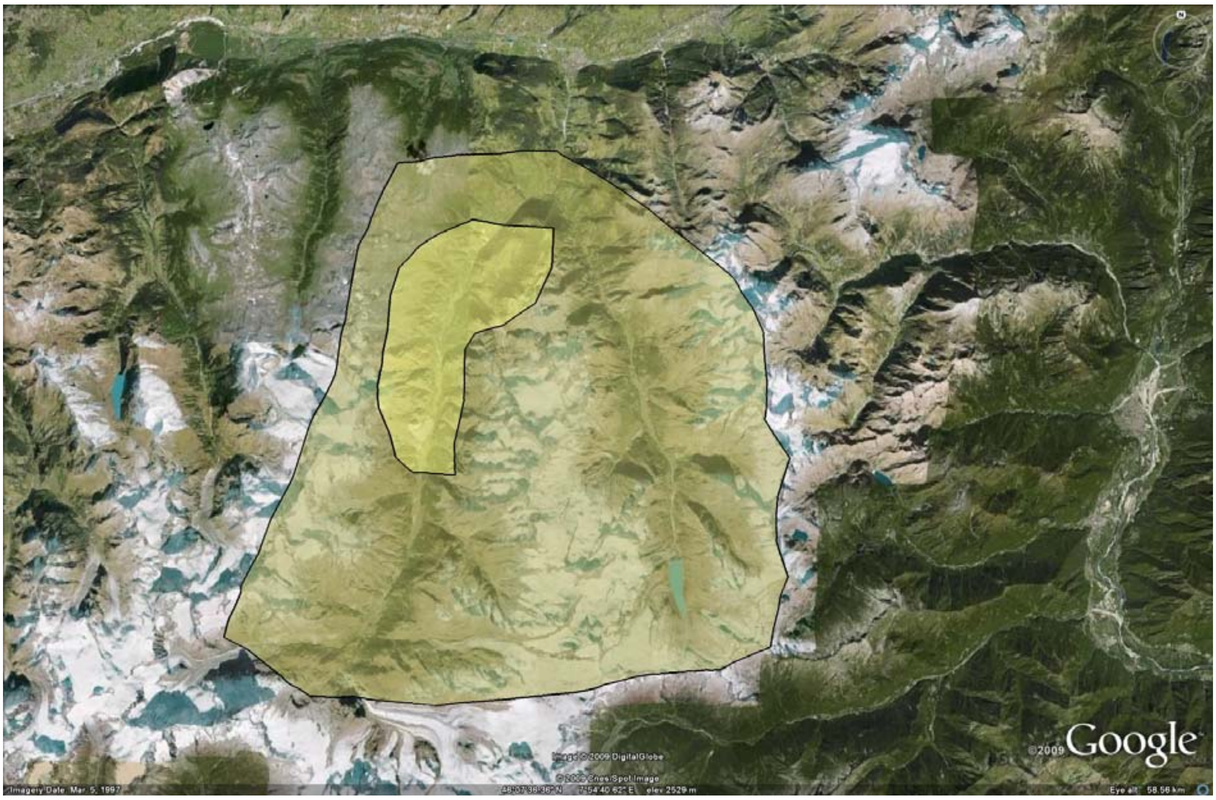


Figure 1. 3D view of the Matter and Saas Valleys showing the overall region and the Matter Valley focus region for Module 3b.

1. Public Data Sources:

The following section provides an overview and description of data available to the COGEAR Project that has been published by Swiss governmental agencies that is integrated into the work presented here.

1.1 Topographic Data

The published topographic data available to COGEAR though licensing agreements between the individual Institutes and the Swiss Federal Bureau for Surface Topography (SwissTopo) includes the 25 m Digital Terrain Model (DTM) for the entire project region. The digital topographic data is published in two formats; an original matrix model in which the data coordinates are composed of X,Y, Z coordinates within the Swiss Coordinate Systen and a Raster model in which only the elevations are provided on a 25m X 25m reference Grid. Each DTM data set corresponds with the 1:25000 topographic maps.

For areas below 2000 m, the digital surface model (DOM) or the DTM-AV can also be acquired at a resolution of 2 m with an elevation accuracy of ±0.5 m, this data is composed of the latest airborne LIDAR data and is most recent topographic data published by SwissTopo. This data is organized and developed for COGEAR in Module 1 by the Institute for Photogrammetry and Remote Sensing (PRS-ETHZ) and the Institute for Cartography (IKA-ETHZ). The DTM data are also available in both the matrix (1 point per 2 m^2 and grid formats (2 m grid). The individual data sets are arranged by the 1:25000 topographic maps and then subdivided into 16 sub-regions. Figure 2 shows the naming protocol for identifying the correct data sets for the location of interest.

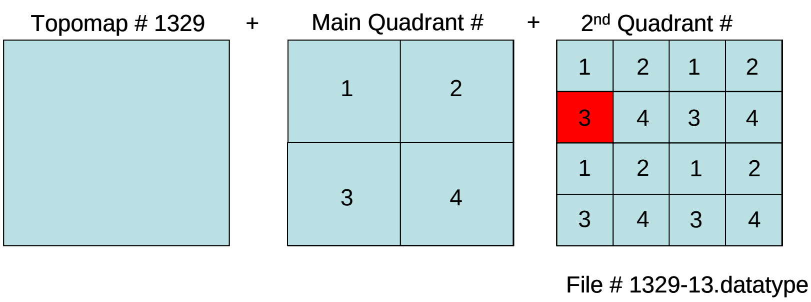


Figure 2. Naming protocol for the identification of the LIDAR DTM data from Swisstopo for the area immediately surrounding Saas Fee.

1.2 Aerial Photographs

Aerial photographs of the project region are also available to project partners that have a licensing agreement with swisstopo, these data are contained within IDES and also organized by PRS-ETHZ (Module 1) . The available areal photographs are ortho-rectified and geo-referenced to the Swiss coordinate system and the available topographic data described above. The image resolution is approximately 0.5 m. These data are organized using the same protocol as with the ATV-DTM data shown in Figure 2, where each 1:25000 map is covered by 16 ortho-images. Additional, areal photographs at higher resolution are available for partner use, PRS-ETHZ should be consulted for availability.

1.3 Geological Data:

Geological maps within the project area are published by Swisstopo and are available at multiple scales depending on the region of interest. Two map types are available; tectonic maps which describe the distribution of tectonic units and major tectonic structures, and geological maps which subdivide the tectonic units into their age and lithologies. Complete coverage of the Project area is provided by the 1:500,000 Geologic and Tectonic Map of Switzerland and the 1:200000 Geologic Map - Sion. Detailed 1:25000 geological maps are available for most of the project region and the entire focus area of the Matter Valley. The distribution of the 1:25000 geological maps available in the project region are shown in Figure 3. The digital geological data available to the project is based on work from Module 1 and developed from the *Atlas of Switzerland*. The Atlas of Switzerland also contains hydrological maps, groundwater maps, and geotechnical maps which are relevant to COGEAR projects. Additional sources to view and work with the geologic data are available through interactive data viewers provided by Swisstopo (map view only).

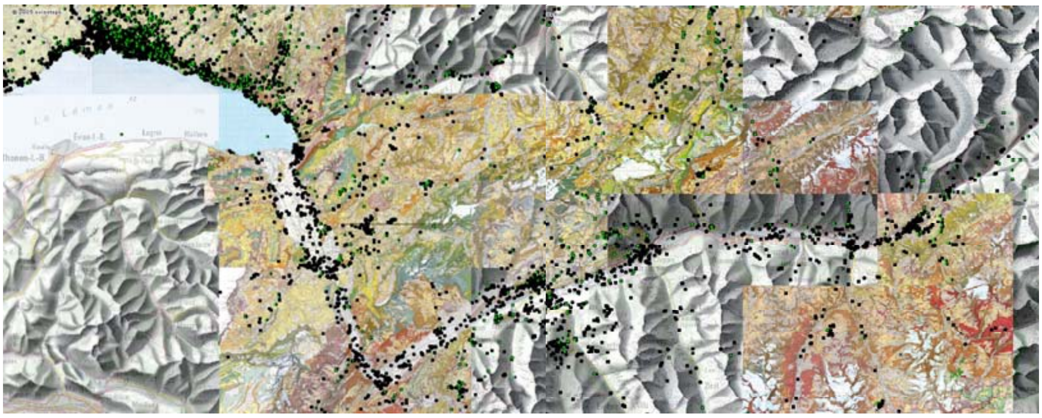
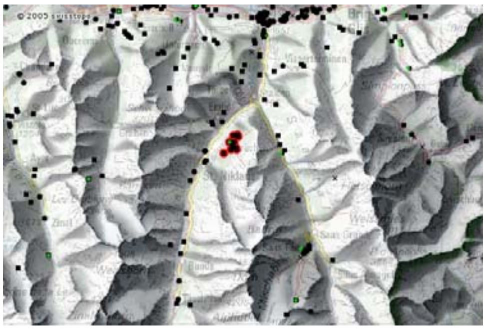


Figure 3. Distribution of 1:25000 Geological Maps published by Swisstopo. Image developed from - http://prod.swisstopogeodata.ch/kogis_apps/webgeol/webgeol.php - black or green markers indicate data reports available from KOGIS.

Figure 3 was developed utilizing the KOGIS application available from swisstopo. This application provides map view access with multiple window sizes to geological and hydrological data available from swisstopo and the Federal Agency for the Environment (BAFU). In addition to the map resources, this site also identifies documents related to geological and hydrological projects where the data is controlled by BAFU. The dots within Figure 3 represent individual data potentially available to interested parties. This data includes boreholes, natural resource investigations, natural hazard investigations, construction documentation, etc. Documents are either available for copying and/or viewing or closed in which special permission is necessary to access the documents. For example, Figure 4 shows the query results for the data available from Graechen, VS. The results indicate that 3 of the reports related to the hydrogeology are available of the area to view and copy (green) while 1 report would require special permission to access (red).



Alles Auswählen | Auswahl aufheben

Punktinformationen

ID *	Dokumentsdatum	Meta-Titel	Ansicht	Kopie	select
20626	1981-12-00	HYDROGEOLOGISCHE UNTERSUCHUNGEN QUELLENSCHUTZZONEN, S - NNE GRäCHEN			
24812	1971-12-21	ETUDE GéOTECHNIQUE POUR BUREAU POSTAL, 200M NNE éGLISE DE GRäCHEN			
25755	1987-11-25	HYDROGEOLOG.UNTERSUCHUNGEN DER QUELLEN IM GRäCHERWALD, SE GRäCHEN			
15853	1980-12-12	GENERELLE HYDROGEOLOG.UNTERS.OELVERSICKERUNG BEI EGGA, NNE GRäCHEN			

*) GIS-Geol ID

Neue Abfrage

Data, Vector25, pixel maps & SwissNames © swisstopo - Disclaimer

Figure 4. Example query for the area of Graechen showing the data available through the GIS-Geol data base.

The second application within KOGIS is the Geological data viewer. In addition to the geological and hydrological maps this application also provides access to many of the theme maps published by swisstopo. For example, themes include Geophysical data, Natural Hazard (permafrost, etc.), Geotechnical data, geological data and surface processes. These data are accessible through the following link: http://prod.swisstopogeodata.ch/kogis_apps/ga/ga.php

2. Project data sources

2.1 Publications

The scientific data included in this report is limited to relevant geologic data related to the research of Module 3b. Numerous geological investigations have been performed in the region of the Matter Valley related to the tectonic development of the Penninic Nappes. These publications describe the general geological framework in the region of the Matter Valley. Most of these publications deal with the tectonic development of the area and provide background information for the work in Module 3b. Selected publications are introduced which contain geologic cross sections which are relevant to the project area in the Matter Valley. Milnes et al. 1981 presents several map views and cross sections through the project region which include the tectonic contacts (Figure 4a) with a legend and major fold axis (Figure 4b) related to major folds including; Vanzone phase folds, (Figure 4c) and Mischable phase folds (Figure 4d).

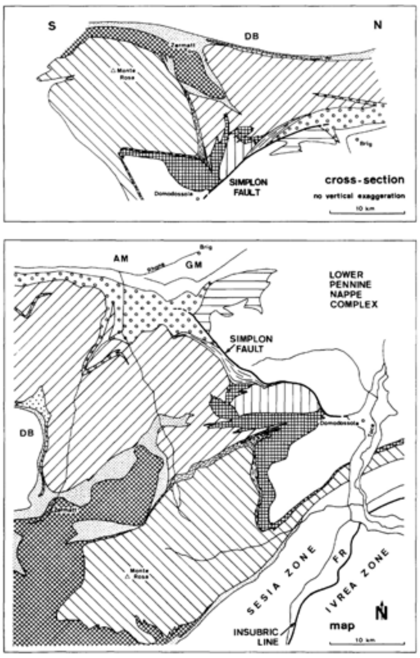
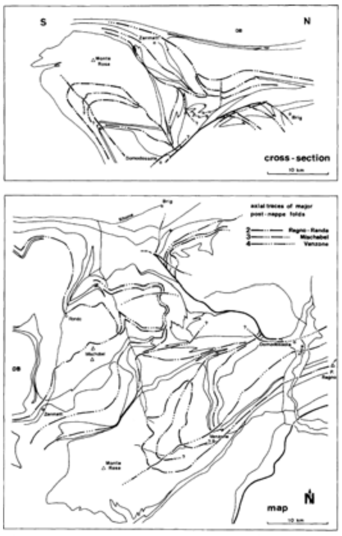


Fig. 1. Composite cross-section and map of the Simplon–Pennine Alps showing the main tectonic units (see Table 1). Abbreviations: DB, Dent Blanche nappe; FR, Fobello–Rimella zone; GM, Gotthard massif; AM, Aar massif. The cross-section has been constructed approximately perpendicular to major fold axes on the basis of all available structural data. Locations are inserted only at the correct structural position and give no indication of relative elevation.

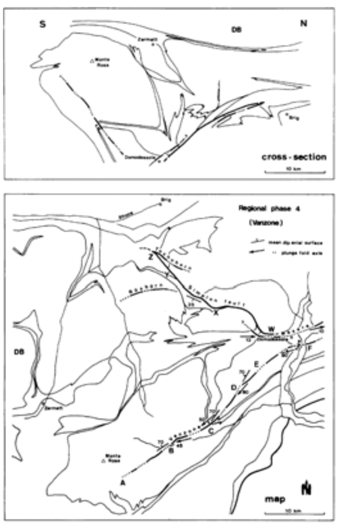
a)

Table 1. Notes on the contents of the tectonic units in the Upper Pennine nappe complex, Simplon–Pennine Alps (see Fig. 1)

Tectonic unit (degree of dismembering)	Signature on Fig.1	Basement (incl. pre-Triassic sediments)	Sedimentary cover (Mesozoic-Tertiary)	Main references
Combin (strong), incl. upper Zermatt Schuppenzone and Theodul-Rothorn zone		small basement flakes normally included in Bernhard or Monte Rosa units:Saas Fee augen-gneiss, Stockhorn crystallines	(Permo-?)Trias very continuous, Lias(?) breccias, Schistes Lustrés with intercalated greenstones (volcanics)	Güller 1947 Bearth 1976 Wilson 1978 Caby *et al.* 1978
Barrhorn (slight)		----------	Briançonnais facies:Trias?, Dogger?(or thrust zone), Malm, u.Cret., Flysch	Ellenberger 1952 Bearth 1964
Zermatt - Saas (moderate)		ophiolite complex, prob. Jurassic (high P metm. ca.90 my ago)	thin but continuous: metacherts and Schistes Lustrés (u.Jur. - l.Cret.?), ophiolitic mélange in places (Riffelberg zone)	Bearth 1967 Dal Piaz & Ernst 1978
Bernhard, also known as Grand St. Bernhard (slight), incl. Portjengrat		mainly polymetm. paragneiss, intruded by late Hercynian granite (Randa gneiss);Permo-Carboniferous sedimentary cover	locally (Permo-?)Trias	Bearth 1963 Bearth 1964 Bearth 1973
Verosso (strong)		paragneiss, some granitic remnants	locally Trias and Schistes Lustrés	Amstutz 1954 Blumenthal 1952
Berisal (slight)		paragneiss, some granitic remnants	locally Trias and Schistes Lustrés	Bearth 1973 Milnes 1974 b
Monte Rosa (slight)		mainly late Hercynian granites and assoc. minor intrusives, remnants of high-grade pre-granitic basement	------------ (Stockhorn crystallines and cover normally assigned to Monte Rosa, here incl. in Combin zone)	Bearth 1952 Reinhardt 1966 Frei & Hunziker 1976
Furgg (mélange)		matrix of mélange mainly Permo-Carboniferous cover of Monte Rosa basement, remnants of ophiolite complex (ultramafic and mafic lenses)	streaks and lenses of Trias and Schistes Lustrés	Wetzel 1972 Frei & Hunziker 1976
Antrona (strong)		ophiolite complex, prob. Jurassic	streaks and masses of Schistes Lustrés, ophiolitic mélange (cf. Riffelberg zone) in places	Blumenthal 1952 Müller 1976 Laduron 1976
Laggin (mélange)		sheared remnants	sheared remnants of ophiolites and ?Trias	Bearth 1973 (not treated there as separate unit)
Stalden - Visperterminen, incl. St.Niklaus syncline and part of Gebidem digitation (moderate)		Permo-Carboniferous sediments	Trias, Cretaceous Flysch formations	Bearth 1973 Burri 1979 Matthes 1980



b) Fig. 2. Composite cross-section and map showing the axial traces of the major post-nappe folds (tectonic boundaries as in Fig. 1), symbols for axial traces are identical in the map and section.



c) Fig. 3. Composite cross-section and map showing details of the Vanzone-phase structures (regional phase 4, see text), axial trace symbol as in Fig. 2.

d) Fig. 4. Composite cross-section and map showing details of the Mischabel-phase structures (regional phase 3, see text), axial trace symbol as in Fig. 2.

Figure 4. a) Tectonic Map and Legend for the project area. b) Major Fold Axis and cross section c) Vanzone Folding d) Mischable folding. After Milnes et al. 1981.

Data related to the deep tectonic architecture has been developed over the past 20 years from seismic data collected during the Swiss Reserch Project NRP 20 – Deep Structures of the Alps (Pfiffner et.al, 1997). Within this project two seismic lines were located in the Matter Valley, Seismic lines W3 (Figure 5a) and W4 (Figure 5b); (Levato et.al, 1993; Marchant & Stampfli. 1997; Steck et.al 1997). These data have been used by many researchers to develop modern geological cross sections (Figure 6) in the project region (Marchant and Stampfli, 1997). This information is relative for understanding the potential role of existing geological structures on the active tectonics in the Valis and hence the potential source locations for major earthquakes which is necessary to evaluate directivity and topographic effects on seismic ground shaking. While not directly in the project area the

Seismic line W2 in Val d'Anniviers (Figure 5c) lies approximately 15-25 km to the west of the Matter Valley and also contributes to the understanding of the local geologic architecture (Dubois et.al, 1990).

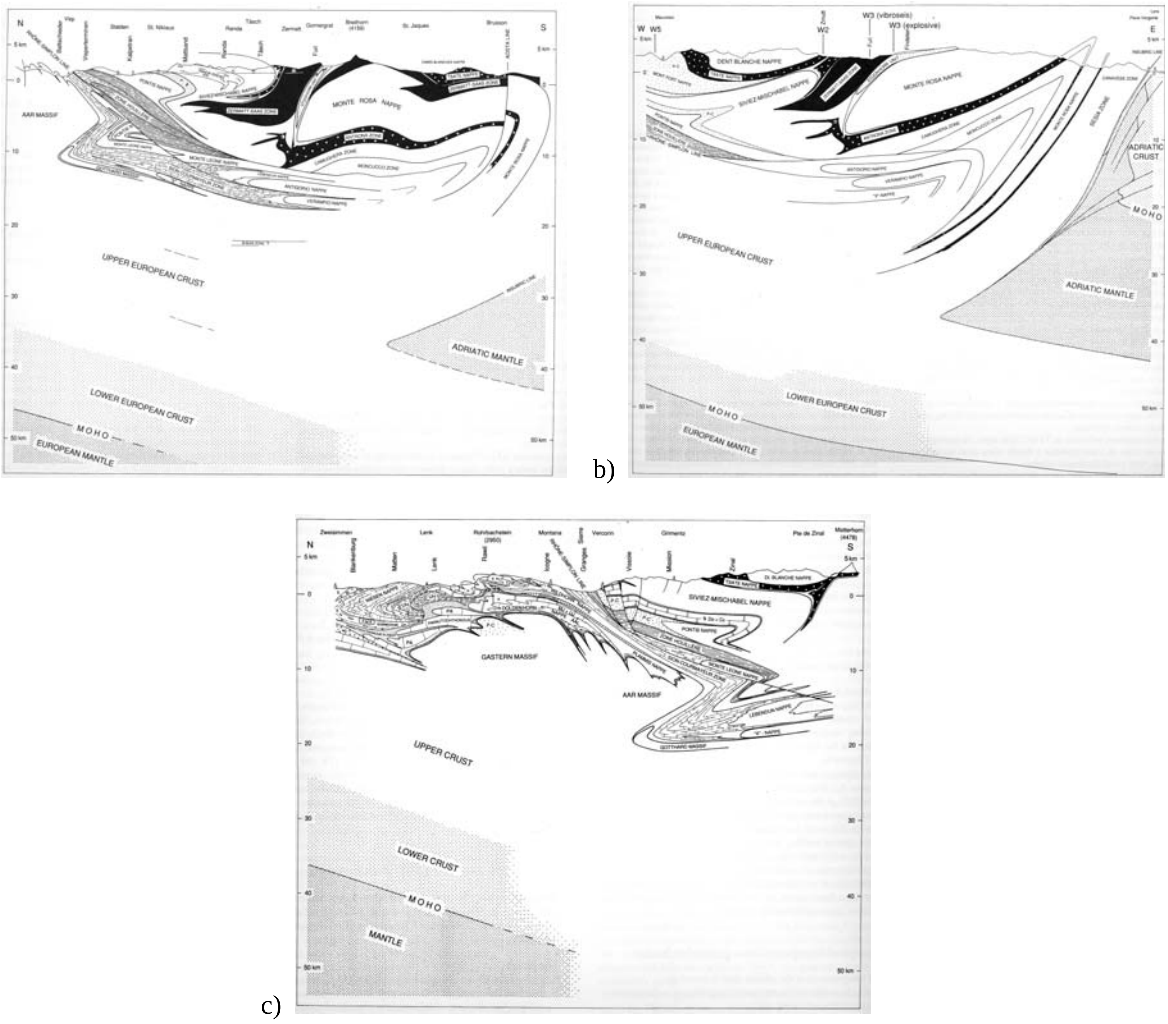


Figure 5. a) North-South seismic profile W3 b) East-West seismic profile W4 c) North-South Seismic Profile Val d'Anniviers. After Levato et.al, 1993; Marchant & Stampfli. 1997; Steck et.al 1997

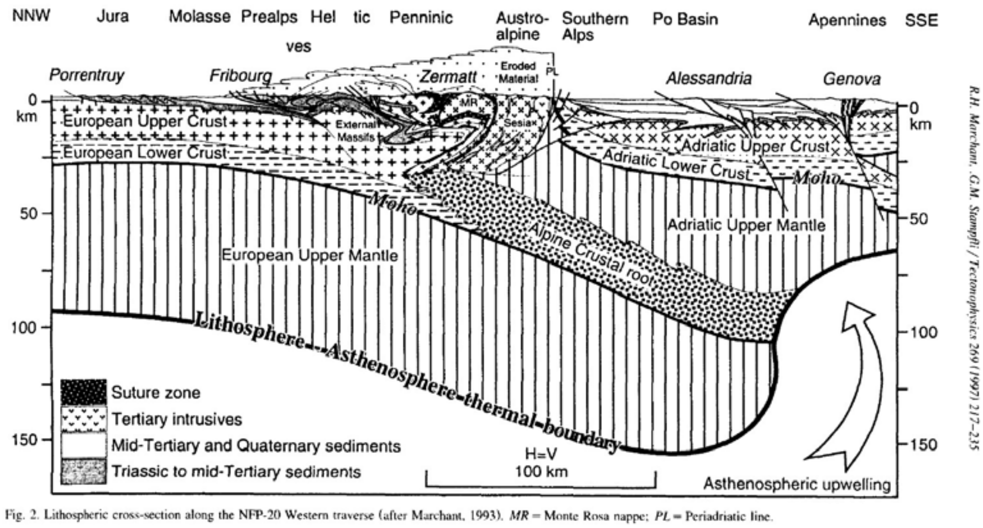


Figure 6. Modern cross sections through the alpine crust. After Marchant and Stampfli, 1997

Detailed cross sections and investigations of the long term displacement characteristics of the Graechen Deep Seated Gravitational Slope Deformation (DSGSD) were presented by Noverraz et.al 1998. The appendix to this report contains geological mapping results and cross sections for the studied instable slopes. For the Graechen DSGSD they present a geological and phenomenon map with measured displacements between 1930 and 1992 (Figure 7). Indicated on this map are 3 geologic cross sections A-A'(Figure 8a), B-B' and C-C' (Figure 8b) and the legend Further studies of the Graechen site as a potential monitoring site within COGEAR are currently in progress and the data is not included in this report. The results should be presented in Deliverable 3b.2.3.1.

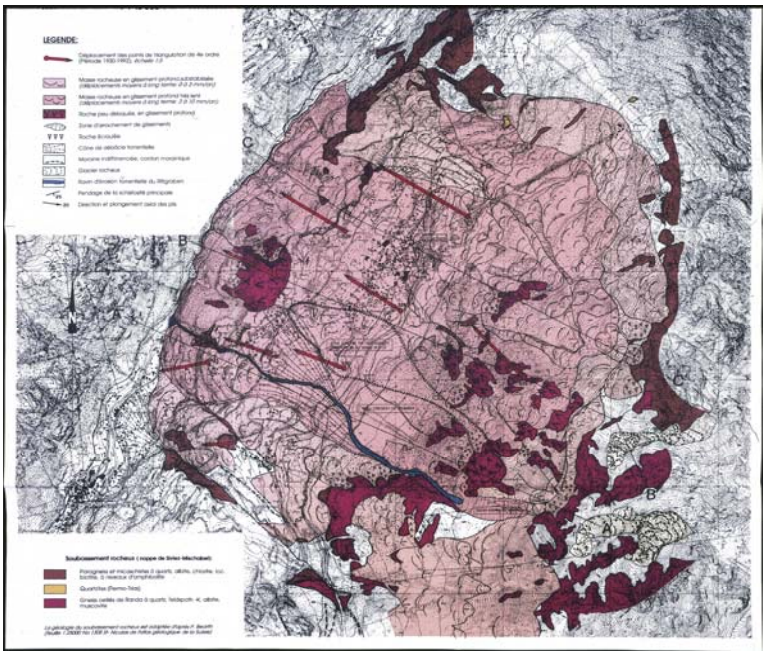
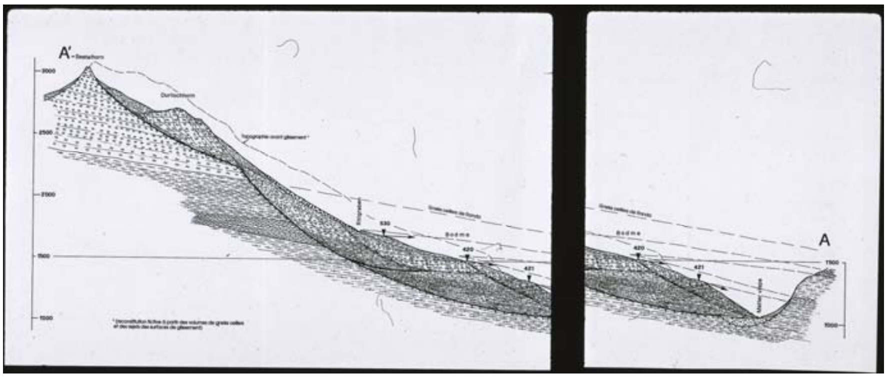


Figure 7. Geological and phenomenon map of the Graechen slope instability. (After Noverraz et.al 1998)

a) 

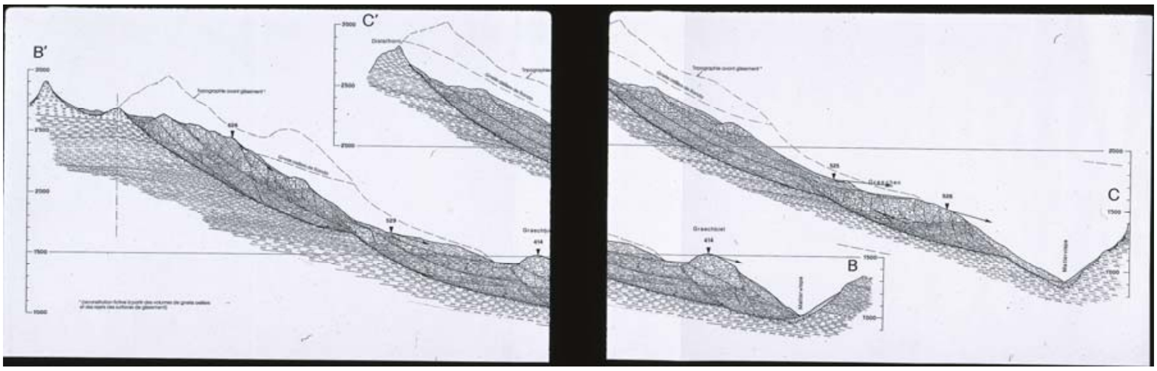
b) 

Figure 8. Cross sections through the Graechen slope instability after Noverraz et.al 1998.

2.2 Internal Publications Matter Valley

The data described in this section was developed or obtained through various research projects conducted by the Engineering Geology Group (EngGeo) and collaborating partners during the past 9 years. The majority of the data is complied within ARC-GIS as shape files or Layers with links to the metadata.

2.2.1 Literature – Matter Valley

The literature described in this section is primarily composed of work based on 3 PhD projectss, 2 MSc projects and 1 BSc Project. Journal publications related to these works are also referenced in this section.

Research conducted by EngGeo related to slope instability and the progressive failure of rock slopes in the Matter Valley was initiated in 2001. The primary focus of this research campaign was to characterize the internal structure and deformation characteristics of the existing Randa Rock slope. A majority of this rock slope failed in the spring of 1991 (Schindler and Eisenlohr (1992) and Schindler et al. (1993)), while the upper portion remained in place but was still deforming. This remaining mass is the focus of research conducted at this site. A detailed engineering geological investigation was performed by Willenberg (2004). Detailed 3-D surface georadar and 3-D tomographic seismic refraction investigations were performed by Heincke (2005) to investigate the internal structure of the unstable Randa rock slope. In order to improve the resolution of the 3-D structural model and determine the frequency and location of micro-seismic events related to slope deformations Spillmann (2007) performed borehole radar measurements and micro-seismic monitoring in the unstable Randa rock slope. This research led to the development of the 3-D structural model for the remaining section of the Randa rock slope and quantified local long term displacement rates.
Zueger (2007) performed engineering geological mapping to evaluate rock slope stability between Randa and Mattsand in the Matter Valley for his Diploma Thesis. The data acquired in this work has been integrated into the ARCGIS database associated with COGEAR and will be discussed later. Joerg (2008) investigated the geological disposition the region immediately surrounding the Medji rock slope collapse. Data developed in this work is integrated into the ARCGIS database.
Lunghi (2007) utilized the DTM-AV LIDAR data in combination with high resolution aerial photographs to identify rock slope instabilities between St. Niklaus and Randa in the Matter Valley. The data and results from this bachelor thesis have been further processed and form part of the data integrated into the ARCGIS database for COGEAR.

Ongoing work in the Matter Valley related to COGEAR include; assessing the relationship between the rock mass structure and Quaternary rock slope development in response to alpine glaciation (PhD Leith); evaluating rock slope instabilities and their geological disposition along the Western flanks of the Matter Valley (PhD Yugsi); and a detailed evaluation of the unstable Randa rock slope deformations (PhD Gischig). These current projects also contribute significantly to the data contained within this report. The following sections briefly describe the available data and provide the corresponding digital data files contained in the appendix of this report.

The most relevant journal publications related to the work in the Matter Valley that are related to this data base are briefly described below. The data related to the 3-D internal structure of the unstable slope at Randa is discussed by Willenberg et al. 2008a. This paper presents a synthesis of the geophysical and geological data developed during the initial research phases at the Randa In-Situ Rock Laboratory. This synthesis resulted in a detailed 3-D rock mass structural model that is necessary to extend modelling into three dimensions. Willenberg et al. 2008b present a summary of the geotechnical, geodetic and geophysical monitoring related to the deformation of the current instability at Randa.

Gischig et al. 2009 present the deformation pattern at the current Randa instability based on the results of ground based InSAR measurements. These results were combined with the high resolution Helimed DTM and the associated orthophotos developed in cooperation with PRS to delineate the key geological structures bounding the instability at Randa. They were able to divide the slope into two distinct regimes, each undergoing a different primary mode of deformation. The upper portion of the slope surface is associated with the highest displacement rates (12 mm/yr) which are interpreted to be forward rotation of structurally bounded blocks. At an elevation of approximately 2250 m the slope angle changes from 60° to 80° and the displacement rates from this point to a distinct basal failure surface at an elevation of approximately 1900 m are uniform with a magnitude of 4.4 mm/yr. This displacement pattern indicates translation of a more or less homogeneous block bounded by major structural features on all sides. This data leads to a much improved estimate of the extent and volume of the unstable mass allowing more reliable analyses and hazard assessment to be performed.

2.3 Geological and Geotechnical Data

Two methods are utilized to compile and observe spatial data for the research in the Matter valley. ARCGIS is utilized for the data related to the site and local scale data while the regional data is maintained in a Google Earth Platform. The data is interchangeable between these two spatial data analysis tools. The majority of the existing data related to rock slope instability along the western flank of the Matter Valley has been integrated into an ARCGIS database (Yugsi, 2009). This compilation of data integrates data analyzed and collected by Yugsi with those available from previous studies in the area as described above. A separate database containing information directly related to the Randa In-Situ Rock Mechanics Laboratory is also contained within an ARCGIS database.

The second method is based on Google Earth and KMZ or KML files to visualize, exchange, and evaluate spatial data. This method is utilized for the regional data associated with the geomorphic evolution of the Matter and Saas Valleys. Both systems are interchangeable as new versions of ARCGIS can both export and import KML files, while shape files can be directly loaded into Google Earth.

2.3.1 Regional Scale Geomorphic Data

Investigations related to the quaternary evolution of the rock slopes in the Matter and Saas Valleys (K. Lieth) have led to data relevant to COGEAR. This data is compiled within Google earth as KMZ files. The primary information currently available from this sub-project includes the distribution of glacial deposits related to the Younger Dryas Glacial Advance, the location of large scale mass movements (modified from Pedranzzini et al. 2009), and mapped glacial trim lines (Kelly et al. 2004). Geological data based on both 1:25000 and 1:500000 geological maps are also included in this data sub-set.

1. Geological Maps (1:25000 and 1:500000)
    a. File: Swiss Geology.kmz
        i. Sections from Geol. Karte #71, #43, #61, #31 (Figure 9a)
        ii. Sections from the Geol. Karte der Schwiez 1:500000 (Figure 9b)
2. Map showing glacial extent based on mapped glacial deposits related to the Younger Dryas including moraines and trimlines (Figure 10)
    a. File: YD-Glaciers.kmz
    b. File: Moraines.kmz
    c. File: KellyTrimlines.kmz
3. Map showing large slope instabilities in the Matter and Saas Valleys
    a. File: slope instabilities.kmz

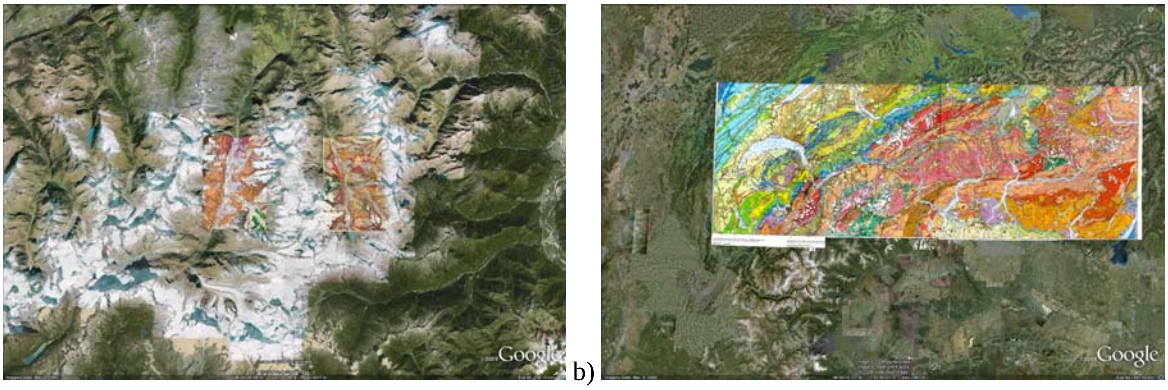
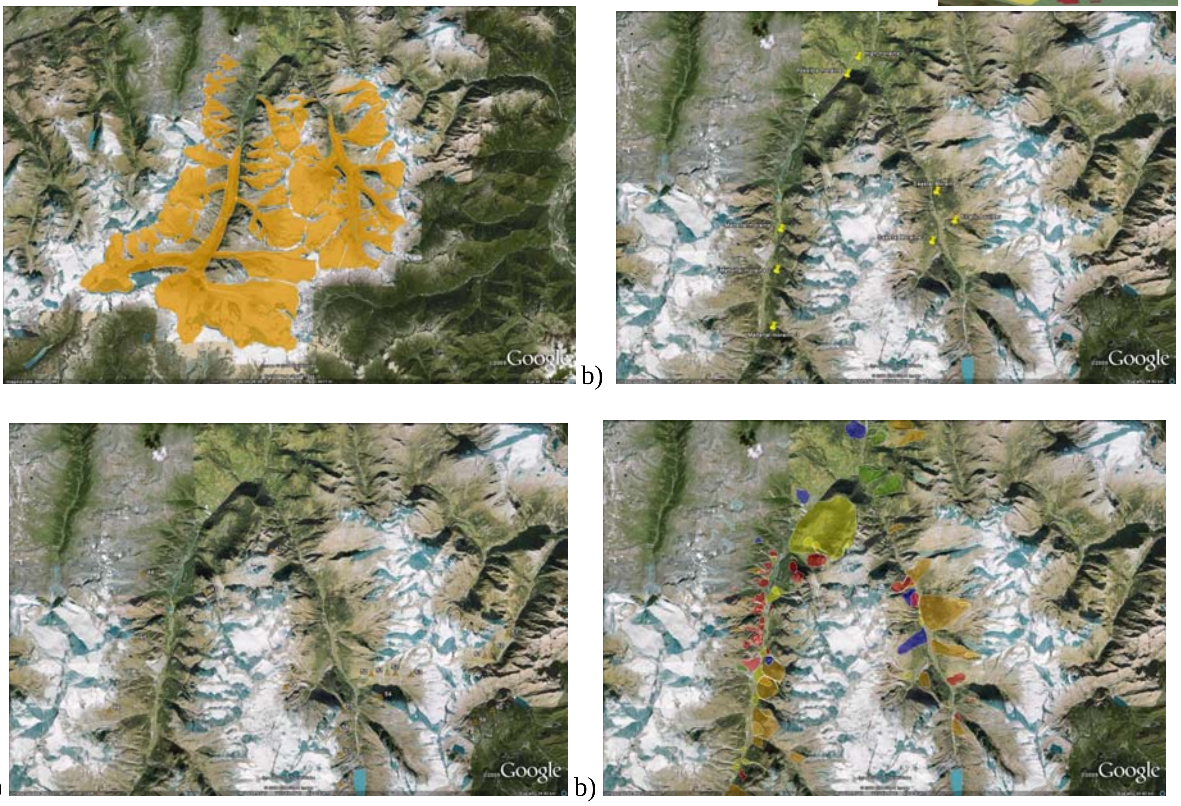
a)  b)

Figure 9. Available geological data in the project region available as kmz files a)1:25000 , b) 1:500000



a) b) c) b)

Figure 10 a) Extent of the Younger Dryas Glaciation b) Location of mapped moraines (Leith, K. unpublished) c) Location of glacial trim lines (created from Kelly et al. 2004) d) Identified slope instabilities in the Project area (Modified from Pedranzzini et al. 2009) .

2.3.2 Western Flank Matter Valley

The data available for the western flank of the Matter Valley between St. Niklaus and Randa is a compilation of geological and geotechnical data developed over the past 5 years during several bachelors and masters thesis's as discussed above and is primarily based on the doctoral work by F. Yugsi. The data collected during these works is assembled in an ARCGIS data base. The topographic (Figure 11a) and photographic data (Figure 11b) for this database are derived from data from Swisstopo in collaboration with the Institute for Photogrammetry and Remote Sensing from COGEAR Module 1. Geotechnical displacement measurements made within the area between St. Niklaus and Randa are not discussed in this report. The full description and data files are described in Deliverable 3b2.2

The database developed for the Matter Valley contains the following layers based on published data from Swisstopo in collaboration with PRS.

1. Below 2000 m the base topographic data is developed from DTM-AV 2m data sets and aerial photogrammetric analyses developed by PRS-ETHZ in cooperation with Swisstopo. Above 2000 m, the base topographic data is developed from the DTM 25 data sets from Randa and St. Niklaus:
   - Raster data file – dtm_united.rdd
   - Data 1308-32, 1308-34, 1308-41, 1308-43, 1328-12, 1328-14, 1328-32, 1328-34 and 25 m DTM 1308, and 1328
2. Aerial photographs developed from high resolution aerial photographs and orthoimages from Swisstopo
   - Layer: orthomosaic.img file: orthomosaic.img
   - Image #'s 20057110512158, 20057110512159, 20057110512160, 20057110512161, 20057110512162, 20057110542219, 20057110542220, 20057110542221, 20057110542222, 20057110542223, 20057110572228, 20057110572229, 20057110572230, 20057110572231, 20057110602278, 20057110602279, 20057110602280, 20057110602281, 20057110632321, 20057110632322, 20057110632323, 20057110632324
3. 1:25,000 geological maps (Randa, St Niklaus)
   - This layer contains scanned and georeferenced images taken from the 1:25000 geological maps Layer: geototal raster file – geototal.

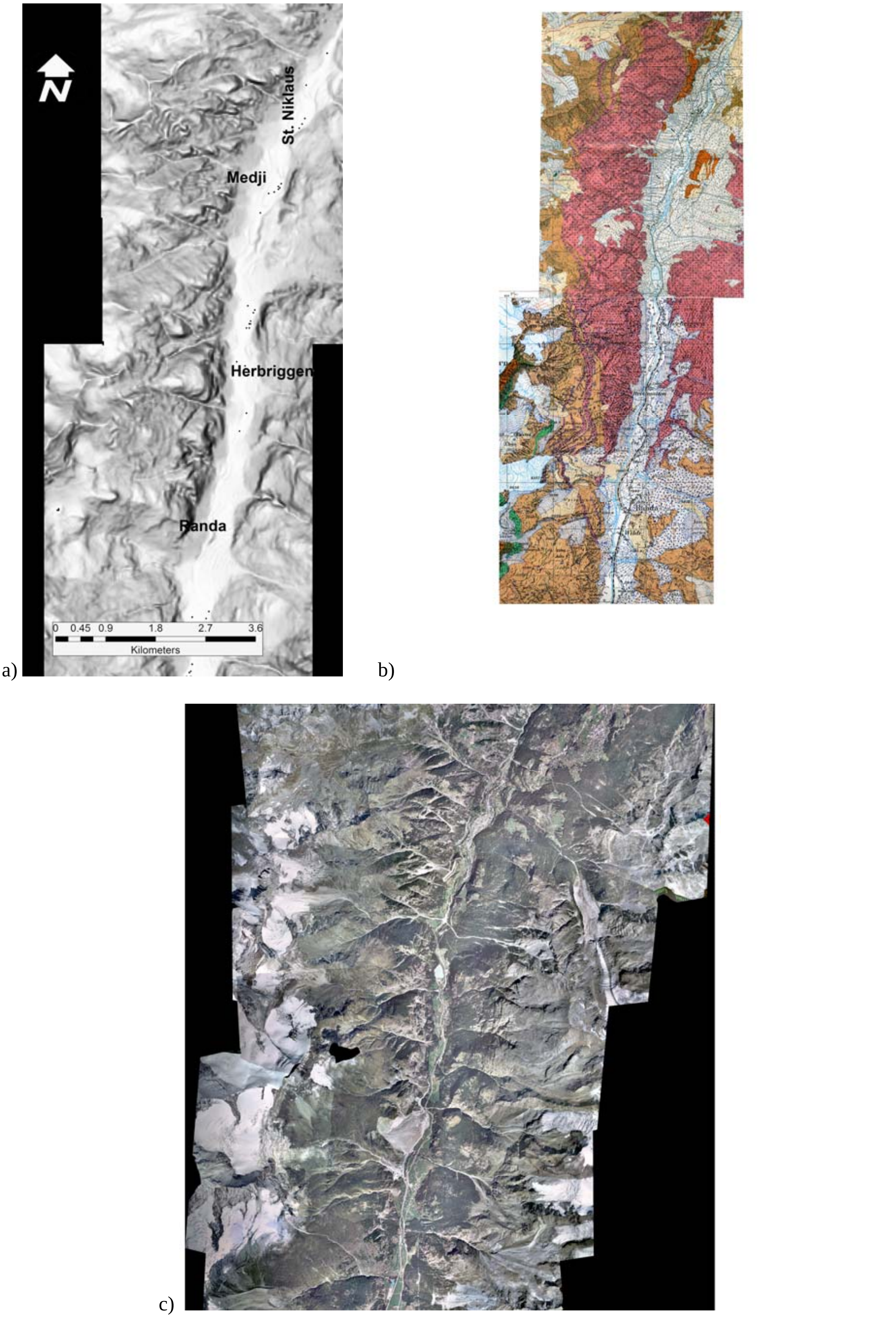


Figure 11 a) Compiled DTM for the Matter Valley b) Geological data 1:25000 for the Matter Valley c) Compiled Orthoimage coverage for the Matter Valley.

Additional geological and geomorphic data developed from field measurements and DTM analysis are included in the data base as shape files which are linked to the meta-data and descriptions. The types of slope instability that are activated during seismic shaking are directly related to the local geological conditions and the rock mass structures. Therefore, data describing the geology and rock mass structure should be directly integrated into regional scale analysis in terms of both hazard identification for risk analyses and post-event emergency response. Data pertaining to the rock mass structure include the location and geometrical properties of discontinuities including foliation, fractures, and faults or fault zones. A detailed geological map developed for the western flank of the Matter valley is currently in preparation and will be included into this database upon publication. Each of the classified discontinuity types is contained within a separate layer in the GIS model.

4. Foliation measurements (Figure 12a): layer – foliation field;
   shape file – foliation 3d.shp
   - This file contains field measurements related to the strike and dip of the foliation structures; the metadata for this file is a text input consisting of foliation dip and dip direction and the location in the Swiss coordinate system.

5. Fault Orientation (Figure 12b): layer – fault orientation;
   shape file – faults.shp
   - This file contains data related to the spatial extent and orientation of mapped faults and fault lineaments in the region from Randa to St Niklaus

6. Open Cracks: layer – inventory cracks;
   shape file – cracks.shp
   - This layer contains the location and extent of mapped open cracks

7. Foliation field dip (Figure 12c): layer – foliation diptrend removed;
   shape file – foliation_merge.shp data field - dip_f

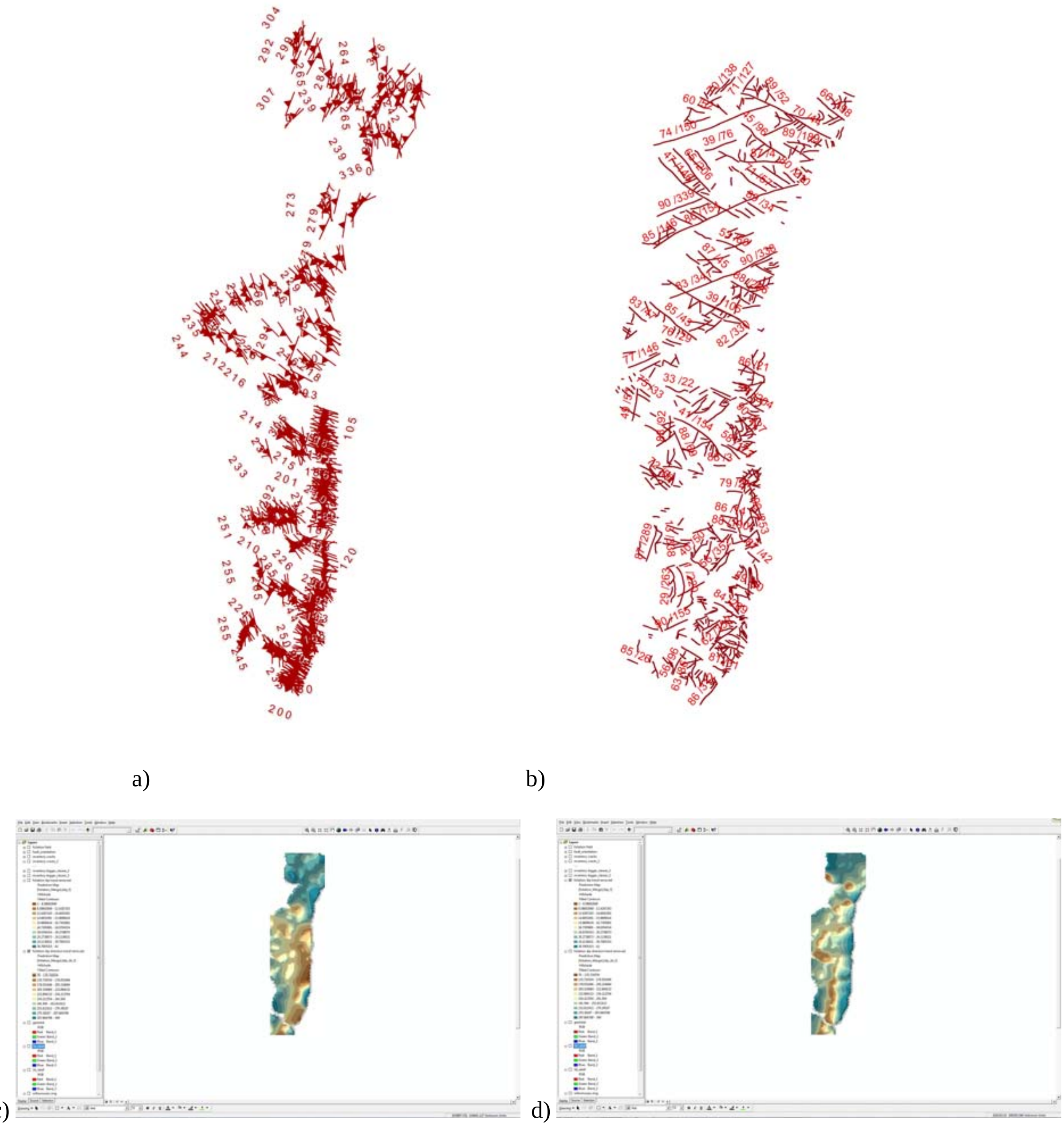
8. Foliation field dip direction (Figure 12d): layer – foliation dipdirection trend rem;
   shape file – foliation_merge.shp data field - dip_dir_f
   - Both the foliation field dip and foliation field dip direction provide a contour map based on the average foliation measurements separated into the dip and dip direction in the cell region. In regions without measurements an extrapolation based on neighbouring data is used.

The results of geomorphic mapping and slope instability classification along the western flank of the Matter valley are contained in four shape files. The first two files are the results of high resolution DTM analysis and aim to identify slopes with different orientations and steepness. These two topographic factors have been shown to influence co-seismic slope instabilities and therefore provide information about a first order parameter for analyzing directional and topographic effects on slope instabilities.

9. Slope aspect and Orientation: Layer – 3d_relief with analysis
   shape files – 3d_relief
   - This file shows the distribution of the 3d slope orientation and dip in the project area

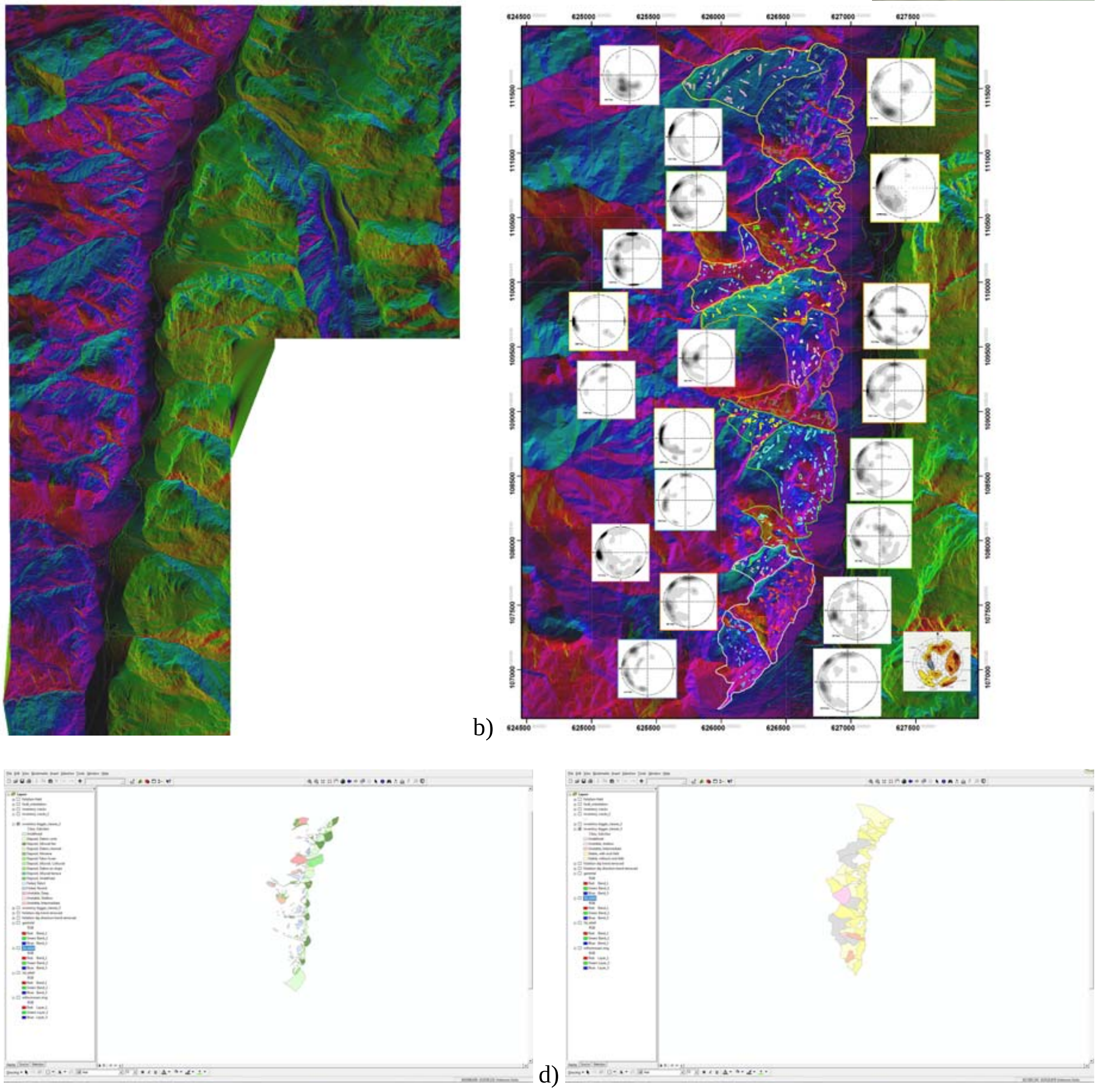
10. Slope deposit Classification: Layer – inventory bigger_classes_2;
    shape file – inventory bigger_classes_2.shp
    - This layer contains information about the type, genesis, and distribution of major slope deposits

11. Slope instability Classification: Layer – inventory bigger_classes_3;
    shape file – inventory bigger_classes_3.shp
    - This file shows the distribution of identified slope instabilities based on their activity



a) b) c) d)

Figure 12. a) Foliation measurements b) Fault measurements c) Foliation trend (orientation) d) Foliation dip available in the ARC-GIS data base (after Yugsi, F. 2010)



a) b) c) d)

Figure 13. a) Slope aspect and dip for the Matter Valley b) Homogeneous structural regions based on foliation measurements combined with the slope aspect and dip data c) Mapped inventory of quaternary slope deposits d) Delineation of slope stability and activity along the western Flank of the Matter Valley (After Yugsi, F., 2010)

2.3.3 Randa In-Situ Rock Mechanics Laboratory

The Randa In-Situ Rock Mechanics Laboratory has been in operation for the last 9 years and a significant amount of local data has been collected in this time. The data presented here is directly related to the work of Willenberg (2004) and current work by V. Gischig as part of COGEAR. The data related to the geophysical investigations at the Randa rock slope is referenced above; however the data must be requested from the Institute for Applied Geophysics (AUG) as needed. Data related to geodetic or geotechnical displacement measurements and their associated systems are integrated into this database and are described in Deliverable 3b2.2..

1. Below 2000 m the base topographic data is developed from DTM-AV 2m data sets and aerial photogrammetric analyses developed by PRS-ETHZ in cooperation with Swisstopo (Eisenbach, 2008??). Above 2000m the base topographic data is developed from the DTM 25 data sets for Randa,
   - St. Niklaus Raster data file – dtm_united.rdd
   - Data: 1308-32, 1308-34, 1308-41, 1308-43, 1328-12, 1328-14, 1328-32, 1328-34 and 25 m DTM 1308, and 1328

2. Aerial photographs developed from high resolution aerial photographs and orthoimages from Swisstopo
   - Layer: orthomosaic.img file: orthomosaic.img
   - swisstopo orthophotos 2005
   - historical paper format stereo pair images

3. DTM Randa (Figure 13a): Layer – DTM+5 raster data file – DTM+5.rdd
   - This raster data is derived from the Swisstopo 25m DTM and a local 5 m dtm

4. Helimed lidar: Layer – Helimed dtm raster data file – helimed dtm.rdd
   - This data is from a lidar derived DTM with a 50cm resolution and spatially covers the Randa rock slide and its immediate surroundings (cooperation with PRS)

5. Pre-failure DTM: Layer – DTMpre raster data file – DTMpre.rdd
   - 25 m pre-1991
6. Rotated DTM: Layer – RandaDTMrot raster data file – randaDTMrot.rdd
7. Rotated Orthophotos (Figure 13b): Layer – rotortho image file – rotortho.img
   - The two rotated files are to analyse the rock mass structure based on a combination of the Lidar DTM and the corresponding photographs. It was necessary to rotate the frame of reference to construct the orthophotos from the original photographs accompanying the LIDAR data.
8. Structure Map Lidar (Figure 13b): Layer – randa structure shape file – randa structure.shp
   - This data represents the spatial location, length and the orientation of discontinuities measured within the 1991 Randa rock slope failure surface from the rotated LIDAR and othophoto data
9. Fault structure map (Figure 14a): Layer – randa faults randa faults.shp
   - These data represent mapped open cracks related to faults or joints that are part of the instability at Randa and are based on the work of Willenberg (2004) and modifications based on new data from Gischig
10. Randa Geology (Figure 14b): Layer – randa geol randa geol.shp
   - This layer contains the local geological conditions as mapped by Willenberg

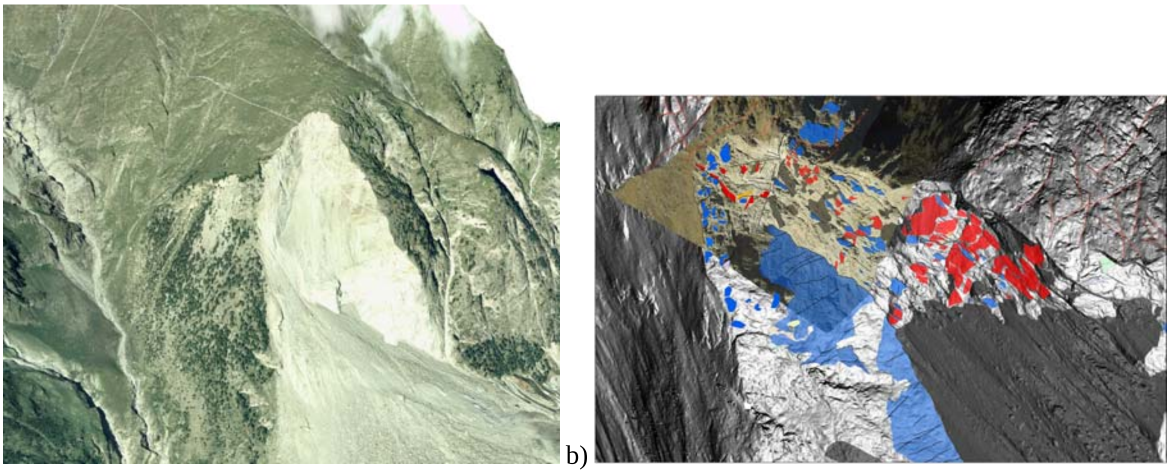
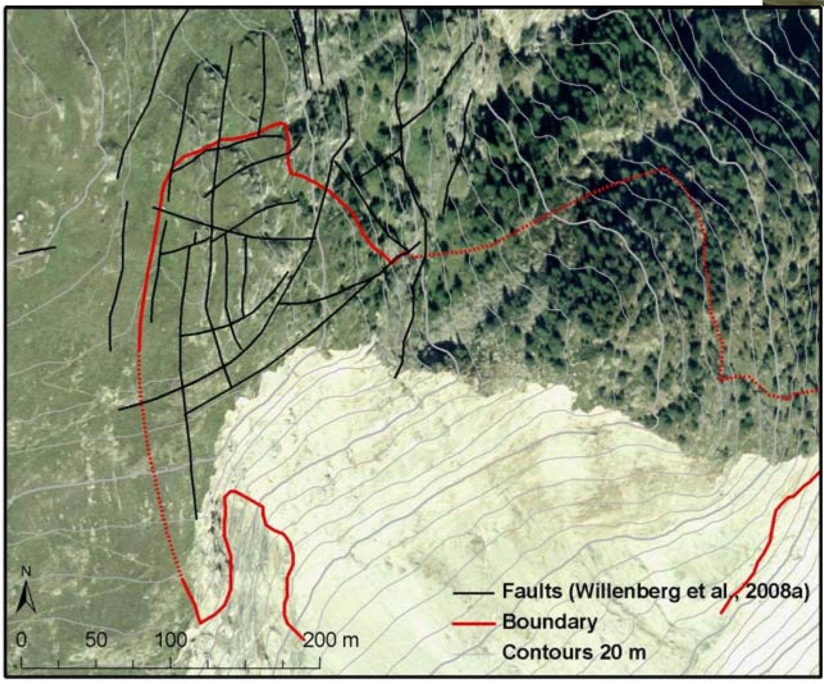
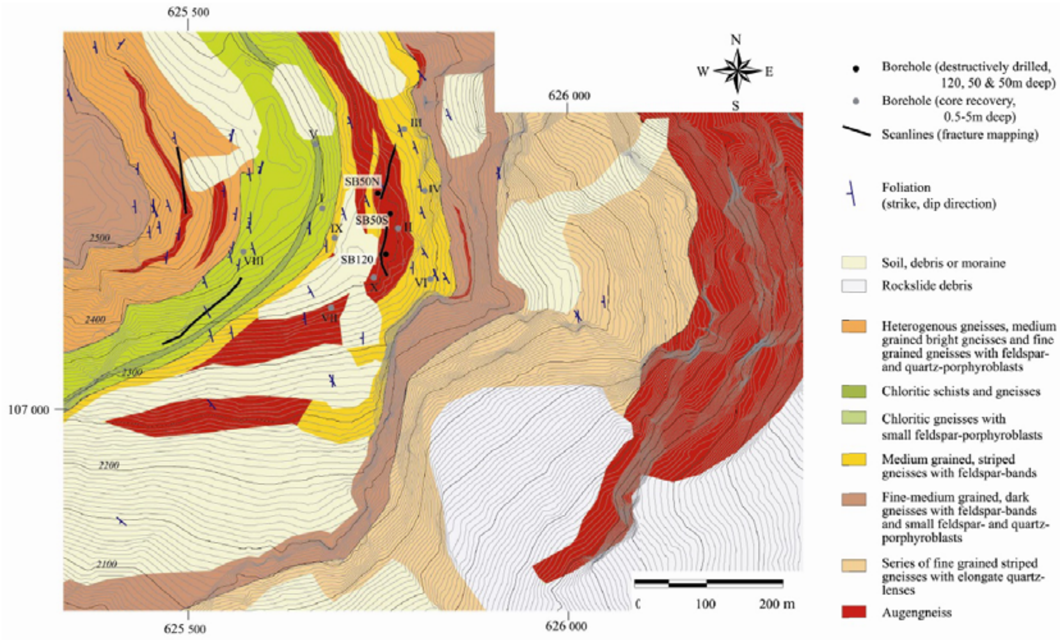
a) b)


Figure 13. a) Orthophotos and 5 m DTM for the Randa site b) Rotated DTM and orthophots for the Randa site with example structural measurements (joint surfaces and potential faults). Gischig,V. 2009.



a)



b)

Figure 14. a) Fault map and boundary of the unstable Randa rock mass (Modified from Willenberg et al 2008a) b) Geological Map and measurement locations at the Randa Site (Willenberg

2.4 Summary

This report describes the basic contents and the data format for the information available related to COGEAR Module 3b. As with any active project, this information is prone to updating and modifications. The data is maintained on the Engineering Geology Server and can be requested by project partners through the Engineering Geology Group. Data developed by research partners is available upon request to the appropriate Institute (AUG).

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Swisstopo Aerial Photographs - orthoimage

Picture number	Flight date	Y	X	Scale	Film type
20057110512158	17.08.2005	623320	117990	1:27900	color
20057110512159	17.08.2005	625150	118010	1:27900	color
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20057110632323	17.08.2005	626830	106070	1:25500	color
20057110632324	17.08.2005	628850	106070	1:25500	color

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